St Mary's University PGCE
Physics - Forces

St Mary's University Twickenham London

Name:…………………………………………………………….

Pre-Session Task

What would you say to a student who says the following:

Statement	Comment
Forces make things move	
If an object is stationary there are no forces acting on it	
When an object runs out of force it stops moving	
If an object is accelerating, it must have a force acting on it	
As an object falls, its speed remains the same	
The weight of an object is always equal to its mass	

Pre-Session Task answers

Statement	Comment
Forces make things move	A **resultant** force can make things **change** their movement (or change their shape)
If an object is stationary there are no forces acting on it	If an object is stationary, there is no **resultant** force acting on it. There are **balanced** forces acting on it.
When an object runs out of force it stops moving	An object cannot 'run out of force'. A **resultant** force opposite to the direction of motion can slow an object down. When the forces are balanced, the object may either stop or continue moving at a constant speed.
If an object is accelerating, it must have a force acting on it	If an object is accelerating, it will have a **resultant** force acting on it.
As an object falls, its speed remains the same	An object falls to earth due to having a gravitational force (weight) acting on it. When the weight is bigger than the resistive forces (e.g., air resistance), there is a resultant force downwards and the object will accelerate.
The weight of an object is always equal to its mass	The weight of an object depends on the gravitational field it is in as well as its mass. An object will weigh less on the moon than on earth.

Task Check List

Activity	*Page*	*Task details*	*Completed* ✓
1	5	Force circus.	
2	6	Draw a forces diagram	
3	8	Draw the resultant forces	
4	9	Which is the correct forces diagram?	
5	10	Compare and contrast the simulations and describe how they could be used in a classroom	
6	11	Relating Newton's second law to everyday life	
7	12	Investigate the relationship between mass and acceleration	
8	13	Calculating the work done when a force moves an object.	
9	14	Investigate the relationship between force and extension for a spring.	
10	15	AQA GCSE Physics Specimen Higher Paper Question on a required practical	
11	19	GCSE Physics required practical activity: Density	
	20	Post session task	

- As you can see from the pre-session task, there are many misconceptions around forces. During this session we will be looking at these in more detail.
- It is important to develop students' skills in analysing forces acting on an object and drawing of force diagrams, and then provide plenty of practice in application.
- The next two tasks are designed to check in with your subject knowledge, but also give you ideas for diagnostic tools to use with your students

Task 1: Forces circus – developing confidence through initial peer discussion

Discuss the forces acting on objects at the stations around the room with a partner. Use the force arrows and blue tack to indicate where forces are acting. Is there any forces you're not sure about?

Task 2: Draw a force diagram of the forces on this boat

Recap: How did you do in naming forces and drawing force diagrams?

1. Forces circus

- Students will have learnt about gravity at primary school. As they get into secondary school, they should be learning that **weight** (or gravitational force) is a more precise way of saying the same thing.
- Upthrust and buoyancy can both be used for the upward force of something that has displaced water. However, students will find **upthrust** easier to spell.
- Students can sometimes confuse thrust and upthrust. **Thrust** refers to a push (e.g. from an engine)
- When an object is at rest on a table, it will have weight acting downwards and a **normal contact force** acting upwards. The upwards 'normal contact' force should not be called a 'reaction force' as students may mistakenly think that it is an equal and opposite reaction to weight. This would be a wrong application of Newton's third law. For Newton's third law, where two objects interact, the forces should be of **the same type** and **act on different objects**. E.g. when I hit a tennis ball with a racket, there is a force on the tennis ball from the racket and there is an equal and opposite force on the racket from the ball.
- Using a force sentence structure can help students to describe the type of force, what the force is acting on and from where the force originates e.g. The <u>gravitational force</u> of the <u>Earth</u> on the <u>mug</u>. The <u>normal contact force</u> of the <u>table</u> on the <u>mug</u>

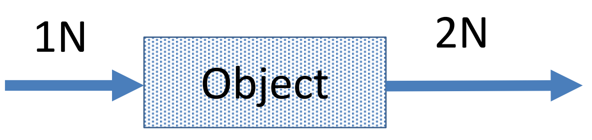
2. Drawing force diagrams

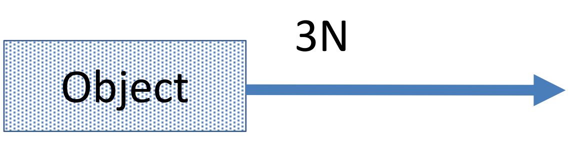
- Are your force arrows attached? Force arrows should be drawn starting from where they are acting (ie. The weight arrow should start from the centre of mass)
- Is the length relative to their overall size?
- Have you focused in on just one object? A force diagram should just focus on the forces acting on one object
- Have you drawn the whole boat, or simplified it to a dot? Either is fine, but if you are drawing the whole boat, make sure you draw the forces from where they are acting. Simplifying the boat to a dot can make it easier to see if the forces are balanced.

Resultant forces

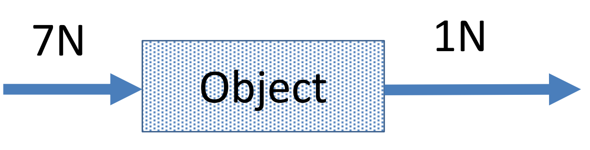
Resultant forces

Often there are a number of forces acting on an object. These may be replaced by a single force that has the same effect as all the original forces acting together. This single force is called the **resultant force**. You should be able to calculate the resultant of two forces that act in a straight line and draw force diagrams to represent forces acting on an object. You should be able to use a free body diagram to show the magnitude and direction of the forces acting on an object. Arrows in the examples below are not drawn to scale.

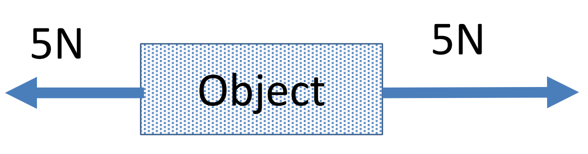




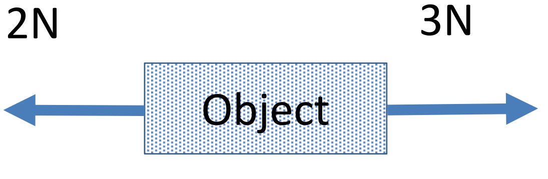
Task F1d: Determine the resultant force in the examples below where two forces act in a straight line.



Draw resultant force



Draw resultant force

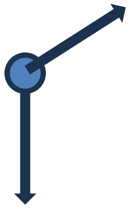


Draw resultant force

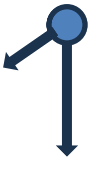
Forces and motion

Task 4
Jackie hits her cricket ball and the ball travel upwards towards the top right-hand corner of the page. Which force diagram below correctly shows the forces acting on the ball at this point? What are the forces called?

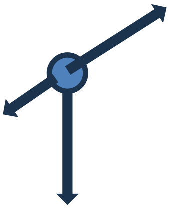
a)



b)



c)



The correct answer is b. There is weight acting on the ball downwards. There is also a small amount of air resistance acting in the opposite direction to the direction of motion.

Once the ball has left contact with the bat, the bat can no longer impose a force on the ball. Therefore, there is no force in the direction of motion. However, students commonly think that if something is moving, it must have a force acting on it in the direction of motion. Actually, if something is moving at a constant speed, it will continue to move at constant speed until a resultant force acts. And if something is stationary, it will continue to be stationary until a resultant force acts.

Newton’s First Law is often quoted as
“An object at rest remains at rest, or if in motion, remains in motion at a constant velocity unless acted on by a net external force”

Essentially it is saying that a resultant force will cause a change in motion

A change in motion can include a change in:
- direction of motion;
- speed of motion;
  - start to move
  - stop moving
  - increase
  - decrease

Task 5
Compare and contrast these two simulations. How might you use them in the classroom?
http://www.physicsclassroom.com/Physics-Interactives/Newtons-Laws/Rocket-Sledder/Rocket-Sledder-Interactive

https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_all.html

Newton's Second Law

When a force is applied to a toy car (for example), it will change its motion. When a bigger force is applied, it will experience a bigger change in motion. Acceleration is proportional to (resultant) force applied.

If the same force is applied to a heavier toy car, the change in motion will be less. Acceleration is inversely proportional to (resultant) force applied.

$$\text{Acceleration} = \frac{force}{mass}$$

$$a = \frac{F}{m}$$

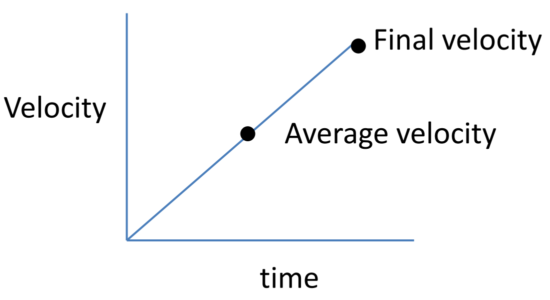
Task 6: What examples can you think of to help students make links between Newton's second law and things that they have experienced in every day life?

GCSE Physics required practical activity: Force and acceleration

St Mary's University Twickenham London

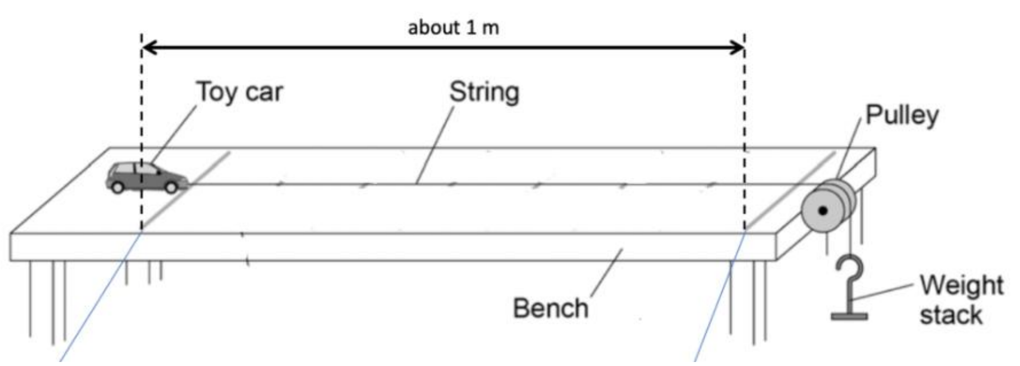
Task 7: Investigate the relationship between mass and acceleration.

Set up the practical as shown below. Time how long it takes for the toy car to accelerate uniformly over 1m. Add additional masses to the car in appropriate intervals and take further time measurements.
Initial velocity = 0 m/s Average velocity = distance/time
Final velocity = 2 x average velocity (as the car is uniformly accelerating)



Acceleration = (final velocity-initial velocity)/time = (2 x average velocity)/time

Create a suitable result table and plot your results.
What does the gradient signify?
Where do you think the errors are in your experiment?
The experiment can be repeated, but changing the accelerating force instead of the mass. For this you increase the proportion of the mass of the system hanging on the weight stack (take them from the car to put them on the stack)



‘Work done’

‘Work’ is another everyday word that is used in physics to have a specific meaning. We have commented that interactions between objects involve forces. Those forces may cause motion. ‘Work done’ is the concept we use to describe the situation when a force causes an object to move over a distance. If there is movement or displacement of the object, we say ‘work has been done’!

To calculate work we multiply the distance moved by the object by the force that was applied to move the object that distance. You should note that the distance measured is the distance moved in the direction of the movement.

work done (j) = force (N) × distance moved (m)

One joule of work is done when a force of one newton causes a movement of one metre.

1 joule = 1 newton metre

Task 8: Calculating the work done when a force moves an object.

1. You push a small box weighing 20N across a carpet covered floor 7metres. How much work have you done?

2. You push against the wall of the building you are in. You push with as much force and you can with all of your muscles! How much work will be done?

3. You hold a box weighing 10N up in front of your face for 1 minute. How much work have you done?

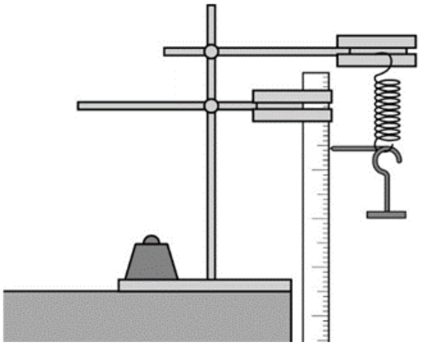
4. You have just completed 225 joules of work when you move a 15kg box onto a shelf. How high off the ground is the shelf?

.

GCSE Physics required practical activity: Force and Extension

Task 9: Investigate the relationship between force and extension for a spring.

Set up the practical as shown on the left.
Ensure you take sufficient readings to allow a graph to be drawn, but not so many that will damage the spring.



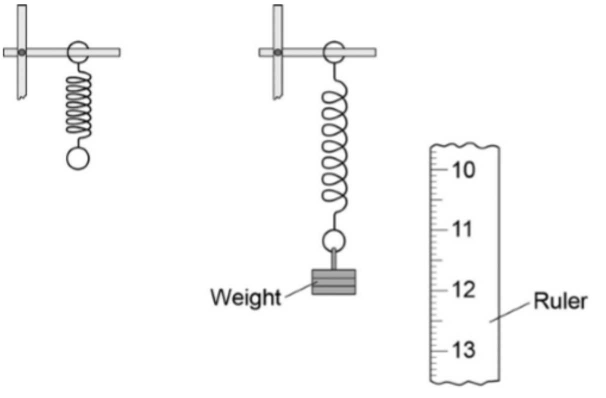
Consider Hooke's Law.
The extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded. That is, if you exceed the elastic limit the spring will be damaged!

Use the space below to record your results.

0 1 A student suspended a spring from a laboratory stand and then hung a weight from the spring.

Figure 1 shows the spring before and after the weight is added.

Figure 1



0 1 . 1 Measure the extension of the spring shown in **Figure 1**.

[1 mark]

Extension = ________________ mm

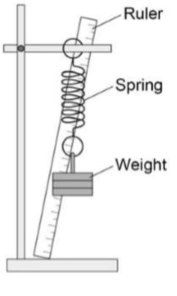
The student used the spring, a set of weights and a ruler to investigate how the extension of the spring depended on the weight hanging from the spring.

Before starting the investigation the student wrote the following prediction:

The extension of the spring will be directly proportional to the weight hanging from the spring.

Figure 2 shows how the student arranged the apparatus.

Figure 2



0 1 . 2 Before taking any measurements, the student adjusted the ruler to make it vertical.

Explain why adjusting the ruler was important.

[2 marks]

____

____

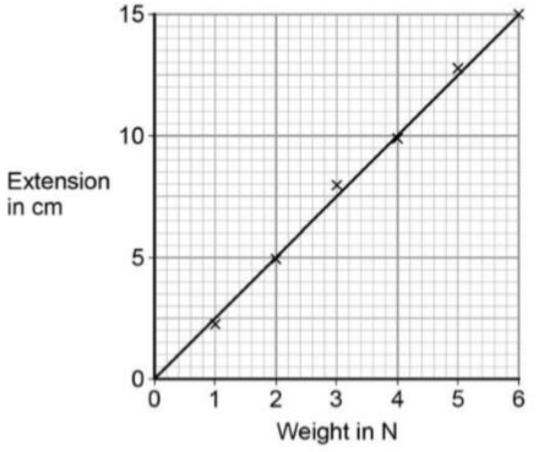
____

____

The student measured the extension of the spring using a range of weights.

The student's data is shown plotted as a graph in **Figure 3**.

Figure 3



0 1 . 3 What range of weight did the student use?

[1 mark]

0 1 . 4 Why does the data plotted in **Figure 3** support the student's prediction?

[1 mark]

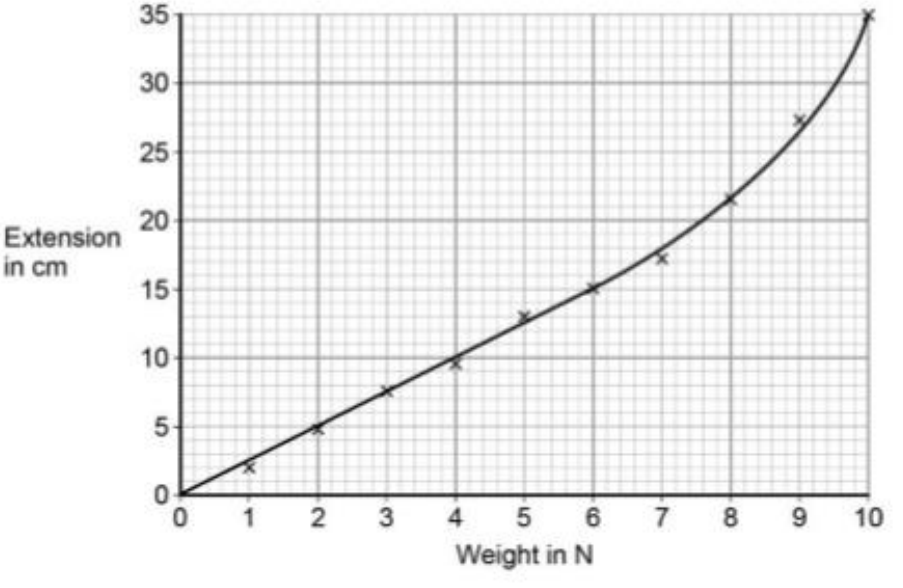
0 1 . 5 Describe **one** technique that you could have used to improve the accuracy of the measurements taken by the student.

[2 marks]

0 1 . 6 The student continued the investigation by increasing the range of weights added to the spring.

All of the data is shown plotted as a graph in **Figure 4**.

Figure 4



At the end of the investigation, all of the weights were removed from the spring.

What can you conclude from **Figure 4** about the deformation of the spring?

[2 marks]

____

____

Give the reason for your conclusion.

____

____

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	accept any value between 12 (mm) and 13(mm) inclusive		1	AO2/2 4.5.3
01.2	to reduce the error in measuring the extension of the spring as the ruler at an angle would make the measured extensions shorter	accept length for extension throughout	1 1	AO3/3a 4.5.3
01.3	1 (N) to 6 (N)	accept from 0 (N) to 6 (N)	1	AO2/2 4.5.3
01.4	gives a straight line through the origin		1	AO3/1a 4.5.3
01.5	any practical technique that would improve the accuracy of length measurement eg use a set square to line up the bottom of the spring with the ruler scale or attach a horizontal pointer to the bottom of the spring (1) so that the pointer goes across the ruler scale (1)		1 1	AO3/3b 4.5.3
01.6	the spring has been inelastically deformed because it went past its limit of proportionality	accept elastic limit for limit of proportionality accept it does not go back to its original length when the weights are removed	1 1	AO3/2a AO2/2 4.5.3
Total			**9**	

Task 11: GCSE Physics required practical activity: Density

Using the equipment provided, make and record appropriate measurements to determine the density of the objects provided. Use the space below to show your thinking used to complete the task.

Post Session Task

St Mary's University Twickenham London

Statement	Comment
Forces make things move	
If an object is stationary there are no forces acting on it	
When an object runs out of force it stops moving	
If an object is accelerating it must have a force acting on it	
Astronauts float because there is no gravity in space	
As an object falls, its speed remains the same	
The weight of an object is always equal to its mass	